International Journal of Electrical and
Electronics Engineering Research (IJEEER)
ISSN(P): 2250-155X; ISSN(E): 2278-943X
Vol. 7, Issue 1, Feb 2017, 33-40

LOAD SHARING WITH PARALLEL INVERTERS FOR INDUCTION MOTOR DRIVE APPLICATION

M. DILIP KUMAR[1], S. F. KODAD[2] & B. SARVESH[3]

[1]*Research Scholar, JNTUA, Ananthpur, Andhra Pradesh, India.*

[2]*Professor and HOD, PESITM, Sivamogga, Karnataka, India*

[3]*Professor, JNTUA, Ananthpur, Andhra Pradesh, India*

ABSTRACT

Multi-level inverters use is becoming more in common these days due to its advantages over conventional inverters. Inverters driven motor drives are very much promising method for efficient operation increasing cost effectiveness. This paper discusses the sharing of induction motor drive load by two parallel multi-level inverters. Parallel inverters driving a load can eventually reduce the rating of devices and hence losses of the system. Faults are common in occurrence due to the presence of switching cells in inverters. Load sharing using parallel inverters connected to a common load can increase the load capacity but this paper is intended to study the performance of each of the parallel inverters with its characteristics and induction motor load characteristics which might be useful in case of any faulty condition in inverters keeping the load capacity unchanged. With two parallel inverter concept of driving induction motor, interfacing inductor sizing is reduced. Diode clamped inverter topology was used for multi-level inverter and was controlled with asymmetrical PWM technique to trigger switches in inverter. The proposed work was simulated using MATLAB/SIMULINK software and results were presented showing characteristics with parallel placed inverter concept of each inverter individually and performance with a single inverter concept.

KEYWORDS: Induction, Drive, Parallel Inverter and Loads Sharing

Received: Dec 13, 2016; **Accepted:** Jan 10, 2017; **Published:** Jan 17, 2017; **Paper Id.:** IJEEERFEB20174

Original Article

INTRODUCTION

Induction motor drive is used almost in many industries as it can give better performance with minimum converters required for its operation. Induction motor operates on AC type of supply and can directly tap the power from supply main grid thus requiring no converter for its operation. But for variable speed operation of induction motor drive, changing terminal voltage and supply frequency will be an effective method of speed control as speed of the induction motor is directly proportional to supply frequency and terminal voltage. Varying voltage and supply frequency maintaining constant voltage to frequency ratio gives better result in speed control with efficiency [1-3]. Varying both voltage and supply frequency with their ratio constant can be achieved by feeding an induction motor thorough an inverter [4-5].

Conventional inverter produces stepped form of output with two-level output containing infinite harmonics in it which insists for high sized filters before induction motor. This increases the cost of the system and availability of high sized filter is a constraint. Producing output with higher levels compared to two-level output can reduces the harmonic distortion at the output of inverter necessitating less sized filters at the output of inverter eventually reducing the cost of the system. Obtaining higher level of output from an inverter is termed as

multi-level inverter. Diode clamped multi-level inverter (DCMLI) is topology producing higher level and with employing diodes as clamping devices.

Load can be shared by the front-end converters in drive application by employing two parallel inverters to drive induction motor drive [6-8]. Two diode clamped multi-level inverters placed in parallel and connected to a common load can drive load effectively increasing the reliability of the system which is very important [9]. With sharing of load by two parallel inverters, ratings of switching devices is reduced which eventually leads to decrease the switching losses. Faults are common in inverters consisting of power electronic static switches for its operation. Out of many common switching faults, switch open and switch short faults are very common to come about which constitutes of around 40% of the total fault conditions. Fault in inverter can disturb the normal operation of the system inverter fed induction motor drive. Malfunctioning of induction motor load can lead to reduced mechanical output as a result decreasing the process output of the plant. Placing two inverters in parallel can give better reliability for the said case as fault in any phase of one inverter out of two can be nullified by the other inverter placed in inverter [10].

This paper presents the parallel inverters concept of driving induction motor drive with two diode clamped inverters placed in parallel together drive induction motor load. The total power sent to induction motor is shared among two inverters equally. Inverters performance is studied while driving induction motor load. The proposed work was simulated using MATLAB/SIMULINK software and results were presented showing characteristics of each inverter individually with parallel operation of two inverters concept and performance on a whole with single inverter concept.

SINGLE DIODE CLAMPED INVERTER FED INDUCTION MOTOR DRIVE

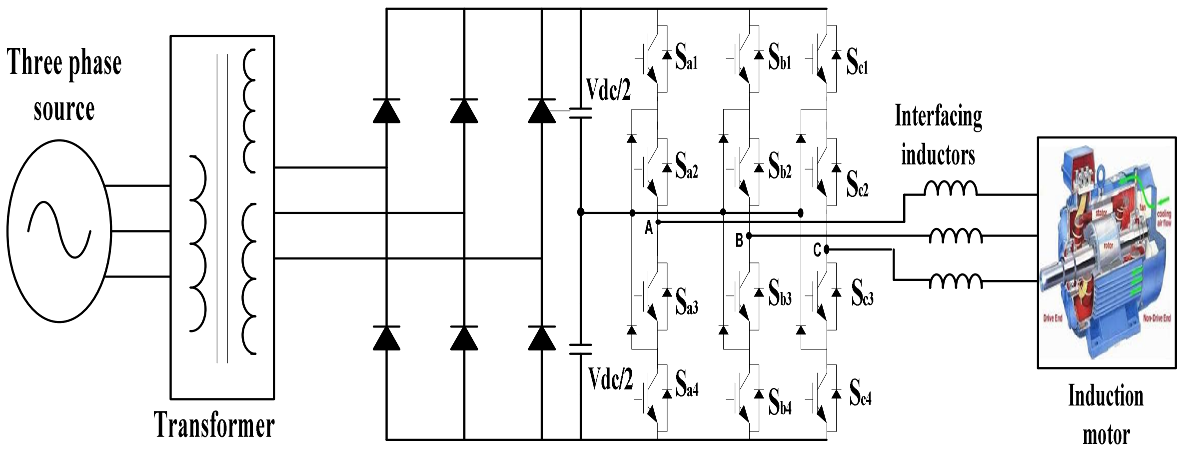

Figure 1: Schematic Arrangement of Induction Motor Drive Fed from Single Inverter

Figure 1 depicts the general circuit representation of single diode clamped multi-level inverter (DCMLI) fed induction motor drive. Induction motor is AC type of machine and needs AC supply. For variable speed operation of induction motor, is fed from inverter. Inverter is a device which converts DC to AC supply and needs a DC source for its operation. Apart from DC link voltage inverter is to be fed from a DC source. The available supply from grid should be of DC type and for this a simple diode bridge rectifier converts AC grid supply to DC type and feeds inverter. A simple diode bridge rectifier consists of two diodes per phase and a total of six diodes to convert three phase AC supply to DC type. A sequential circuital representation was shown in figure where supply is fed to diode bridge rectifier for conversion from AC grid supply to DC and feeding inverter. A simple diode clamped inverter consists of diodes and power electronic static switches for its operation. Inverter consists of four static switches per phase and employs diodes as clamping devices.

Though diode clamped inverter has a problem of having more number of diodes as number of levels in multi-level inverter is increased but as basic inverter it is considered for the investigation. Induction motor load is completely driven from a single inverter and total of the load will be burden on single inverter.

INDUCTION MOTOR DRIVE FED FROM PARALLEL INVERTERS

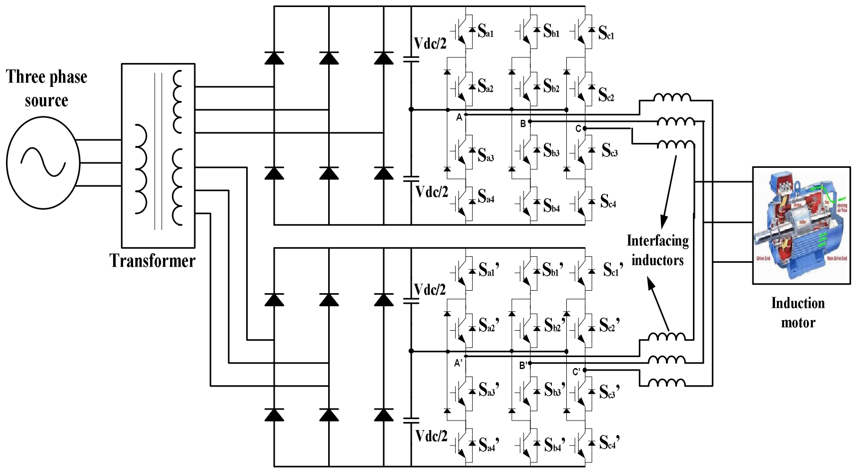

Figure 2: Schematic Arrangement of Induction Motor Drive Fed from Two Parallel Inverters

Figure 2 illustrates the schematic circuit arrangement of induction motor load driven by two parallel placed diode clamped multi-level inverters. The schematic arrangement consists of a transformer to share the complete load required by the induction motor. The AC type of supply is rectified to DC type using two diode bridge rectifiers placed in each of the parallel paths. The rectified DC in each parallel path is fed to DC link voltage and later to diode clamped inverter for the supply to be inverted to AC with variable voltage at desired value and supply frequency required to operate induction motor with variable speeds. Two parallel inverters were fired using asymmetrical PWM technique. Current sharing between the two parallel inverters helps in reducing the rating of switching components which leads to reduction in switching losses compared to induction motor drive driven from a single inverter. Load sharing between two parallel inverters can also reduce the interfacing filter sizing. Current shared between the two parallel paths requires less sized power diodes used for rectification process.

RESULTS AND DISCUSSIONS

Induction Motor Drive Fed from a Single Inverter

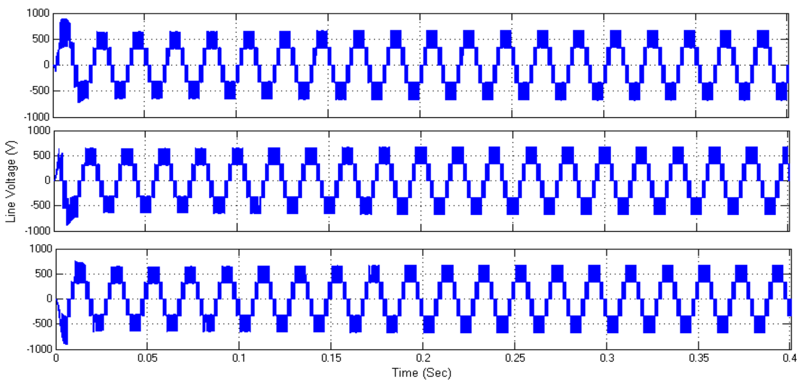

Figure 3: Three-Phase Line Voltages of Inverter

Three-phase line voltage of inverter feeding an induction motor drive is shown in figure 3. The line voltage in each phase is maintained at 700V peak value. Each phase is displaced by 120^0 phase shift.

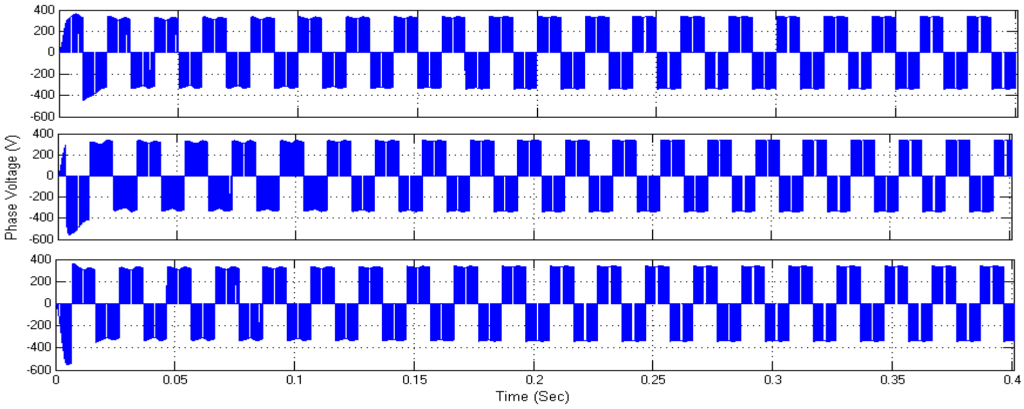

Figure 4: Three Phase Voltages of Inverter

Three-phase voltages of inverter feeding induction motor drive were shown in figure 4. Each phase is displaced by 120^0 phase shift and maintained with 450 peak value.

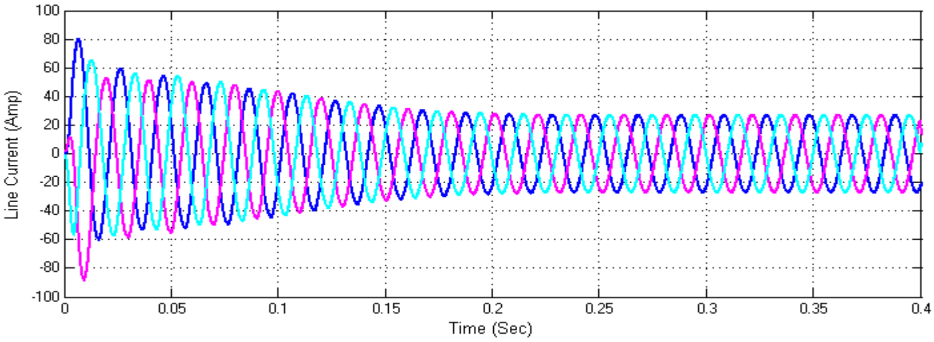

Figure 5: Three Phase Line Currents of Inverter

Three phase line currents of inverter shown in figure 5. With initial transition, line currents settle with peak of 30A approx. three phase line currents were balanced in nature.

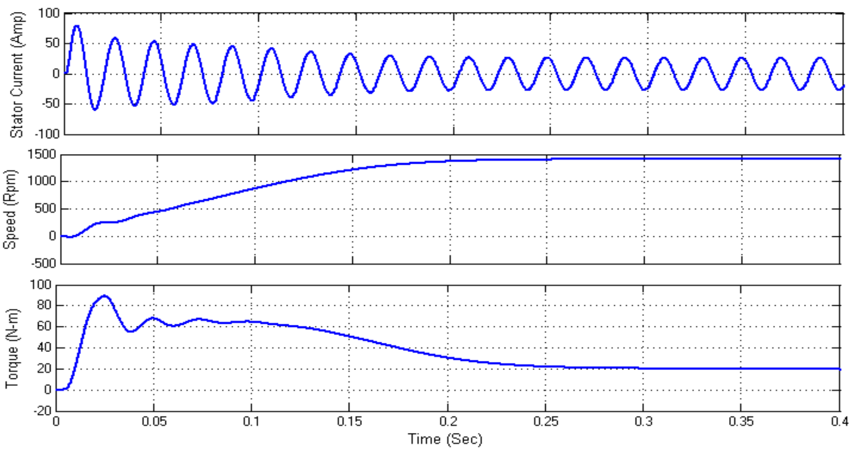

Figure 6: Performance Characteristics of Induction Motor Drive

Induction motor performance characteristics were shown in figure 6 with stator current, speed and torque

waveforms. Stator current is maintained at constant 30 A peak value with speed at 1440 RPM. Torque is maintained at 20 Nm and maintained constant after initial transition.

Induction Motor Drive Fed From Two Parallel Inverters

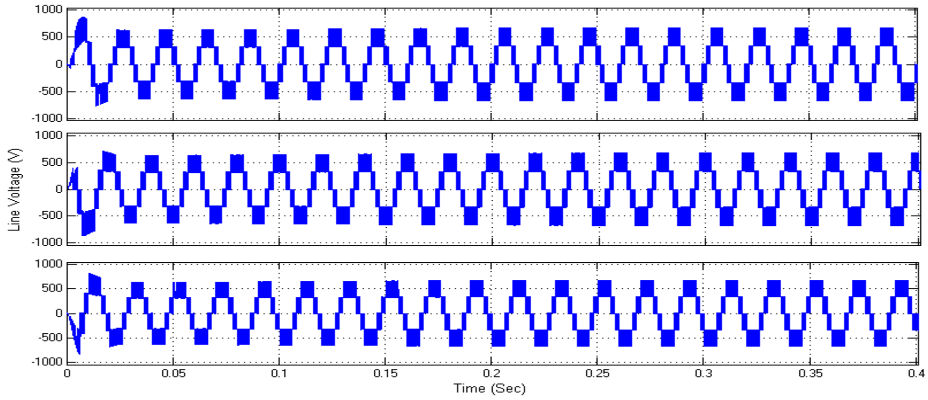

Figure 7: Three-Phase Line Voltages Corresponding to Inverter-1

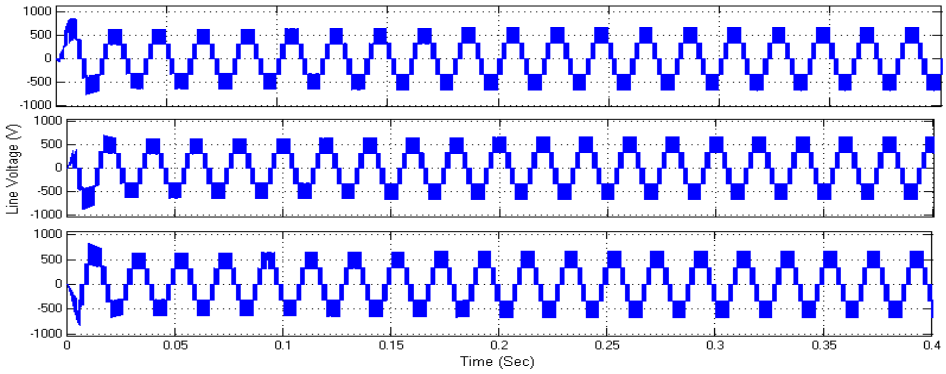

Figure 8: Three-Phase Line Voltages Corresponding to Inverter-2

Three-phase line voltages of inverter-1and inverter-2 when induction motor drive is fed from two parallel inverters were shown in figure 7 and figure 8 respectively. The line voltage in each phase is maintained at 700V peak value in each of the inverter. Each phase is displaced by 120^0 phase shift.

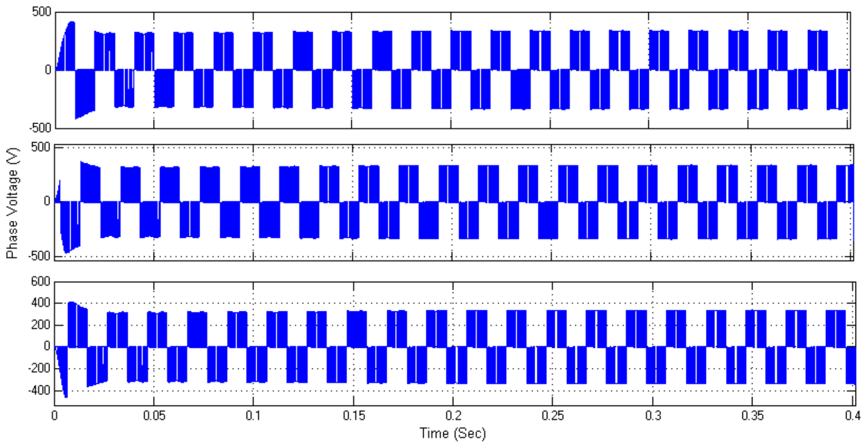

Figure 9: Three Phase Voltages Corresponding to Inverter-1

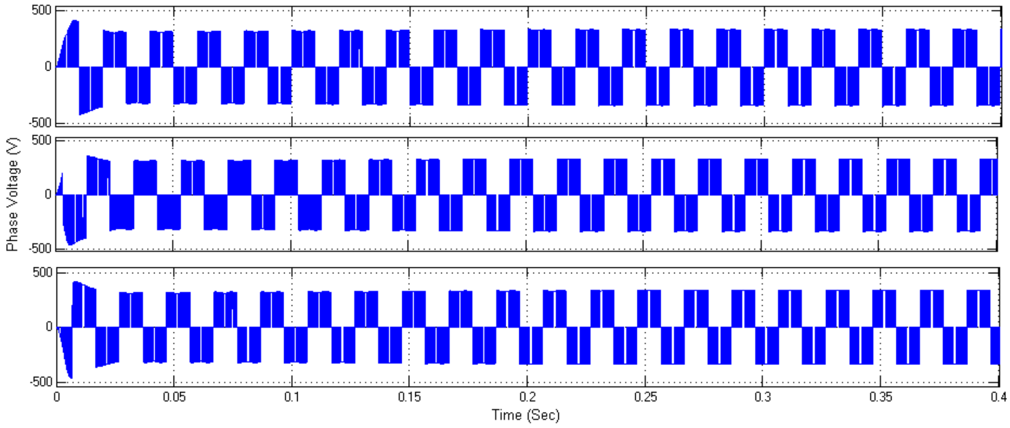

Figure 10: Three Phase Voltages Corresponding to Inverter-2

Three-phase voltages of inverter-1and inverter-2 when induction motor drive is fed from two parallel inverters were shown in figure 9 and figure 10 respectively. The phase voltage in each phase is maintained at 350V peak value in each of the inverter. Each phase is displaced by 120^0 phase shift.

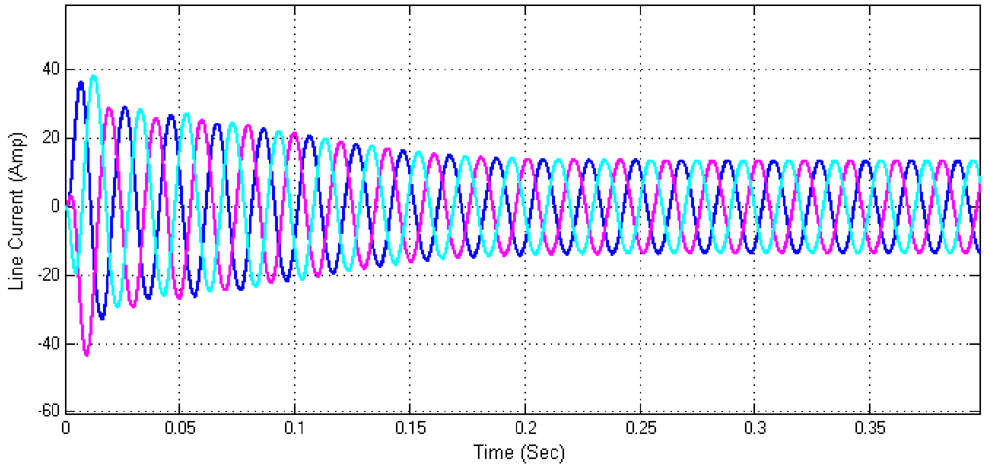

Figure 11: Three Phase Line Currents Corresponding to Inverter-1

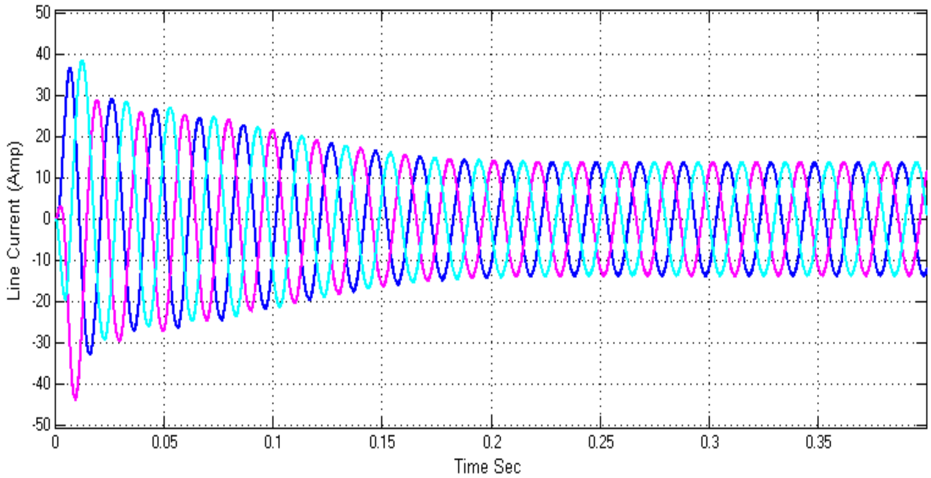

Figure 12: Three Phase Line Currents Corresponding to Inverter-2

Three phase line currents of inverter-1 and inverter-2 were shown in figure 11 and figure 12 when induction motor is fed from two parallel inverters sharing load. Line current of each phase in inverter-1 is at peak value of 15 A and inverter-2 15A giving total current of 30A together when driving an induction motor. The current in each inverter is shared while in case of single inverter driving induction motor, total current of 30A is been fed from single inverter increasing the current rating.

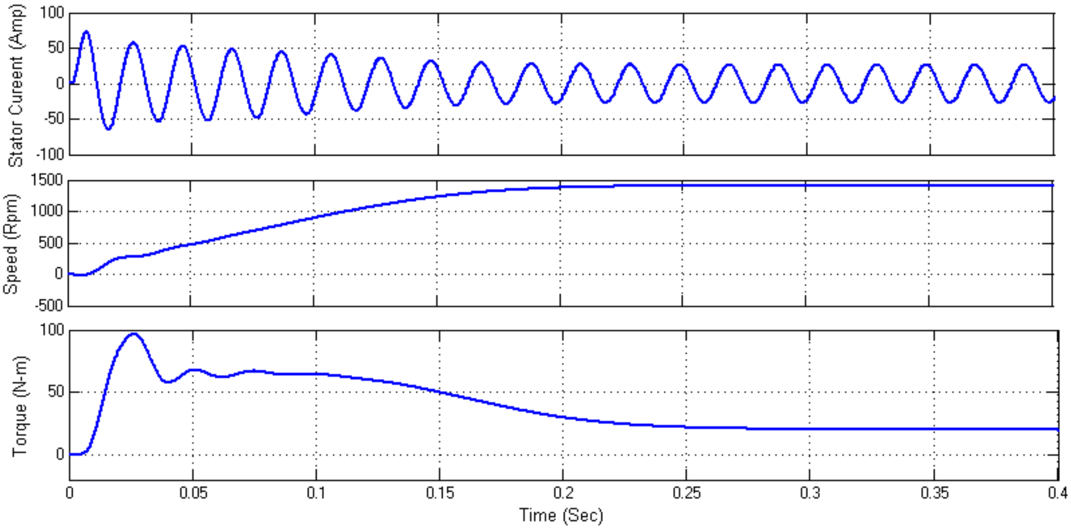

Figure 13: Performance Characteristics of Induction Motor Drive

Induction motor performance characteristics were shown in figure 13 with stator current, speed and torque waveforms. Stator current is maintained at constant 30 A peak value with speed at 1440 RPM. Torque is maintained at 20 Nm and maintained constant after initial transition. Though the induction motor was fed from two parallel inverters sharing currents, induction motor performance remains same as that of induction motor fed from single inverter.

CONCLUSIONS

Induction motor for drive application is been extensively used in industries. For obtaining variable voltage and supply frequency to drive induction motor with variable speeds, inverter will be handy in operation. Parallel inverter for load sharing to drive induction motor was examined in this paper. With single inverter driving induction motor, the total of the load current will be handled by single inverter increasing the ratings of switching devices. By using two parallel inverters, the load current is shared among two inverters thus reducing the current ratings of power switches which are concluded from presented results. The phase and line voltages remain same in magnitude thus giving same induction motor performance results with single and two inverter topologies. With two parallel inverter topology, current rating reduces and as a result losses are reduced improving the efficiency.

REFERENCES

1. *K.Vijaya Bhaskar Reddy, G.V. Siva Krishna Rao, "Modeling And Simulation Of Modified Sine PWM VSI Fed Induction Motor Drive" International Journal Of Electrical Engineering & Technology (IJEET), Volume:3, Issue:2, 2012, Pages:343-351*

2. *A.O.Amalkar, Prof.K.B.Khanchandani, "Design And Implementation Of Sensorless Speed Control For Induction Motor Drive Using An Optimized Extended Kalman Filter," International Journal Of Electronics And Communication Engineering & Technology (IJECET), Volume 6, Issue 3, March (2015), pp. 33-43© IAEME*

3. *M.S.Aspalli.1, Asha.R2, P.V. Hunagund, "Three Phase Induction Motor Drive Using IGBTs And Constant V/F Method," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 1, Issue 5, November 2012, pp 463-469.*

4. *Alfredo,Thomas A. Lipo and Donald W. Novotny, "A New Inductio Motor V/f Control Method Capable of High-Performance Regulation at Low Speeds" IEEE Trans. Industry Applications, Vol. 34, No. 4 July/ August 1998.*

5. *M.S.Aspalli, Veerendra.D, P.V.Hunagund, A New generation VLSI approach for V/F control of Three-Phase Induction Motor. Proceedings of the International Conference on VLSI,Communication and Instrumentation, April7th -9 th, 2011, Kottayam, India.*

6. *Y.Wei, C. Min, J. Matas, J. M. Guerrero, and Q. Zhao-Ming, "Design and analysis of the droop control method for parallel inverters considering the impact of the complex impedance on the power sharing," IEEE Trans. Ind. Electron., vol. 58, no. 2, pp. 576–588, Feb. 2011*

7. *T. Kawabata and S. Higashino, "Parallel operation of voltage source inverters," IEEE Trans. Ind. Appl., vol. 24, no. 2, pp. 281–287, Mar./Apr. 1988*

8. *H. Ming, H. Haibing, X. Yan, and H. Zhongyi, "Distributed control for ac motor drive inverters in parallel operation," IEEE Trans. Ind. Electron.,vol. 58, no. 12, pp. 5361–5370, Dec. 2011.*

9. *C. Jiann-Fuh and C. Ching-Lung, "Combination voltage-controlled and current-controlled PWM inverters for UPS parallel operation," IEEE Trans. Power Electron., vol. 10, pp. 547–558, Sep. 1995*

10. *N. M. Abdel-Rahim and J. E. Quaicoe, "Analysis and design of a multiple feedback loop control strategy for single-phase voltage-source UPS inverters," IEEE Trans. Power Electron., vol. 11, no. 4, pp. 532–541,Jul. 1996.*